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Mr. Nigel Robinson
United States Environmental Protection Agency
Region II – Emergency & Remedial Response Division
290 Broadway – 19th Floor
New York, New York 10007-1866

Subject: Chemsol Superfund Site
Matrix Diffusion in Rock

Dear Mr. Robinson:

At the request of de maximis, inc., enclosed are two journal articles that document research conducted by Dr. Edward Sudicky as presented at the Fractured Rock 2001 conference sponsored jointly by the USEPA and the Canadian Ministry of the Environment. One of the re-occurring themes of the conference was the difficulty associated with the clean up of contaminants associated with DNAPL in fractured rock, an issue currently at the forefront of our discussions regarding the on-site groundwater remedy at the Chemsol Superfund Site. This difficulty is primarily related to diffusion of the solvent into the matrix of the rock, which was specifically addressed by Dr. Sudicky of the University of Waterloo. In Dr. Sudicky's words, there is good news and bad news. The good news is that matrix diffusion will limit the areal extent of DNAPL in the subsurface. The bad news is that once the contaminant is in the rock matrix, it is extremely difficult to remove.

In the article titled "Numerical Simulation of Multiphase Flow and Phase Partitioning in Discretely Fractured Geologic Media", Dr. Sudicky and his co-authors conclude

> "An example problem involving DNAPL in a single vertical fracture surrounded by a low permeability but porous matrix showed that the process of diffusion of dissolved solute to the matrix transfers significant amounts of contaminant to the matrix. Removal of contaminant from the low permeability matrix by flushing the fracture with uncontaminated water relies on the process of reverse diffusion, which is very slow."

Obviously, the problem is significantly compounded when dealing with numerous fractures and the water within the fractures also contains concentrations of the same solvents present in the rock matrix. The affect of this slow reverse diffusion process is illustrated by the rebound of contaminant concentrations in pumping wells. Because the reverse diffusion process is so slow, water surrounding an actively pumped well has a low residence time and the concentrations decline with time. However, when the pump is turned off and the groundwater flow velocities are

reduced to natural conditions, the dissolved concentrations rebound to near their historical levels. The difficulties associated with cleaning up DNAPL sites are explicitly recognized in the attached article titled "Importance of Rock Matrix Entry Pressure on DNAPL Migration in Fractured Geologic Media". In this journal article, Dr. Sudicky and his co-authors state:

> "Moreover, if DNAPL is present in the rock matrix even in small quantities, the effectiveness of source-zone restoration technologies that rely on chemical or water flooding is likely to be poor because most of the flow induced will be channeled through the fracture network and contact with the DNAPL in the matrix will be limited. As such, we hold little optimism that DNAPL-contaminated zones in porous fractured rocks having non-negligible matrix entry pressures can be restored with technologies that are available today."

We continue to believe that these, and other previously submitted data, support our position with respect to the installation of extraction wells within the source area and hope that the attached articles are useful in our forthcoming discussions on this topic scheduled for April 20, 2001.

Please do not hesitate to contact us if you have any questions with regard to the attached journal articles.

Sincerely,

Brown and Caldwell

Gary J. DiPippo, P.E.
Vice President

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